Combining circularity and LCA: Quality assessment and substitutability of recycled plastic from HHW

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Combining circularity and LCA:
Quality assessment and substitutability of recycled plastic from household waste

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Substitutability and plastic waste

Plastic from household waste (HHW) is heterogeneous and dirty
→ reduced quality or functionality

The substitutability*, α, is important for environmental performance of plastic recycling and depends on the functionality, φ (Vadenbo et al., 2016):

$$\alpha^{rec:disp} = \frac{\varphi^{rec}}{\varphi^{disp}}$$

φ^{rec} ← Recycled plastic
φ^{disp} ← Displaced plastic (virgin)

Functionality = ability to fulfil the demands on the market (Eriksen et al., 2018).

Quantified from the quality, *Q*, (***step 1***) and market shares, *MS*, (***step 2***):

Always for virgin plastic

$$\alpha^{rec:disp} = \frac{\varphi^{rec}}{\varphi^{disp}} = \frac{MS(Q)^{rec}}{MS(Q)^{disp}},\quad MS(Q) = \begin{cases} MS_{high}\ for & \boxed{Q = high} \\ MS_{medium}\ for & Q = medium \\ MS_{low}\ for & Q = low \end{cases}$$

* For use in LCA. Also called substitution ratio, B-factor, etc.

Step 1: Quality identification

- Quality = ***potential*** applicability of the recycled plastic (in what applications can the material substitute virgin plastic?)
- Eight applications were divided into three quality levels based on strictness of legislation regarding chemical composition (see table).
- The applicability can be found from ***contamination*** of plastic waste after sorting and before reprocessing

Applications	Quality	Legislation strictness
Food packaging	High	High
Toys, electronics, pharmaceuticals	Medium	Medium
Construction, Non-food packaging, automotive, all others	Low	Low

Step 2: Quantification based on market shares - Example

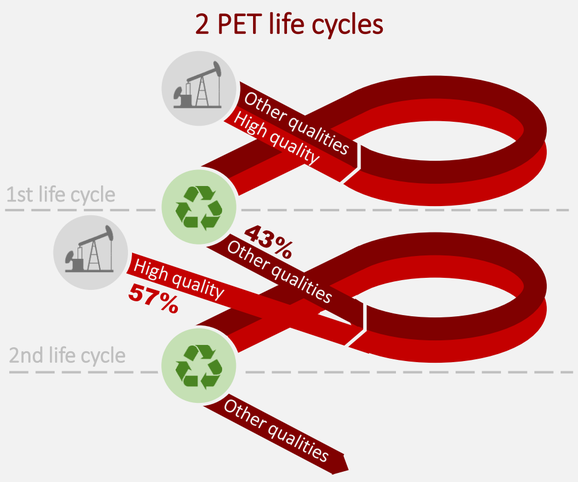
Applications	Unit	European polymer markets				
		PET	HDPE	LDPE	PP	PS
High quality	**%**	***57***	***27***	***54***	***18***	***15***
Food packaging	%	57	27	54	18	15
Medium quality	**%**	***0***	***3***	***4***	***6***	***11***
Toys	%	0	0	0	0	0
Pharmaceuticals	%	0	1	1	1	1
Electronics	%	0	2	3	5	10
Low quality	**%**	***43***	***70***	***42***	***76***	***74***
Construction	%	0	23	6	8	42
Non-food packaging	%	42	23	18	20	18
Automotive	%	0	6	2	13	0
Others	%	1	18	16	35	14
Total	**%**	***100***	***100***	***100***	***100***	***100***
$MS(Q)^{rec}$ value						
Q = High	-	1	1	1	1	1
Q = Medium	-	0.43	0.73	0.46	0.82	0.85
Q = Low	-	0.43	0.70	0.42	0.76	0.74

Eriksen et al. (2018)

The table shows:

- The market share [%] of the different applications on the individual polymer markets relevant for plastic in HHW.
- The corresponding *MS* value [-] for *Q* = high, medium and low for all recycled polymers.

The MS value represents the part of the market in which the material in question can substitute virgin material and thereby close the loop.



Example (PET from HHW):

Source separated mixed PET from HHW (including high quality plastic in food packaging and low quality in bottles for soaps) recycled into low quality PET.

Q^{rec} = Low, Q^{disp} = High

$$\alpha^{rec:disp} = \frac{0.43}{1} = \mathbf{0.43}$$

Discussion and conclusion

- Recycling of plastic from household waste into ***high, food-grade quality*** is necessary to close the individual polymer loops.
- Especially, a large part of the PET and LDPE market rely on high quality food packaging → the ***substitutability*** for medium and low quality recycled material is considerably ***lower than values previously used in LCA literature***.
- Mixed plastic from HHW are currently not recycled into high quality --> separate collection through refund deposit systems does.

References

Eriksen, M., Damgaard, A., Boldrin, A., Astrup, T.F., 2018. Quality assessment and substitutability of recycled plastic from household waste. Journal of Industrial Ecology [*under revision*].

Vadenbo, C., Hellweg, S., Astrup, T.F., 2016. Let's Be Clear(er) about Substitution: A Reporting Framework to Account for Product Displacement in Life Cycle Assessment. Journal of Industrial Ecology. http://doi.org/10.1111/jiec.12519

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